Development of a Peduncle Belt as a Medium to Long-Term Tag Attachment Platform for Cetacean Studies

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LONG-TERM GOALS

To develop a recoverable, noninvasive medium to long-term tag attachment platform which would enable detailed data sets to be collected over extended periods of time (multiple days to multiple months) and would aid in understanding natural whale behaviors and assessing anthropogenic impacts on vulnerable populations.

OBJECTIVES

- To develop a peduncle style tag and tag deployment system as a means of attaching medium to long-term tags to free swimming whales. Two systems are currently under development:

  1) a net gun deployed peduncle tag for large whales

  2) a pole deployed peduncle tag for small whales

- To demonstrate the potential of the peduncle style tag as a benign medium to long-term, noninvasive tag attachment platform either through field trials or in a captive animal setting

APPROACH

Net gun deployed peduncle tag for large whales
A net gun mounted on the bow of a 17 ft runabout has been designed to remotely deploy a padded harness around the tail stock of a whale as it raises its flukes on a terminal dive (Figure 1). The regular net typically used with the net gun has been replaced with a custom designed 10 ft x 15 ft open rectangular lasso with a trailing line running back to the tagging boat. Half pound cylindrical weights are attached to each of the lasso's four corners and loaded into the four barrels of the gun using an o-ring seal. The net gun uses a blank .308 cartridge to propel the weights out of its four barrels, and the splay of the gun barrels ensures that the corners of the lasso are widely spread to fully deploy the loop. Once the lasso clears the fluke tips, a spring powered retraction device starts the cinching process. As the loop closes, a custom designed carabiner clips onto the eye ring of the lasso, latching the 10 ft padded harness closed into a loose loop around the peduncle. Continued pressure on the trailing line to

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the boat triggers a lightweight breakaway on the carabiner, releasing the weighted lasso line from the whale and leaving only the padded harness encircling the peduncle. This peduncle attachment can be used with two different tag configurations: 1) a towed telemetry buoy and 2) a “charm” tag. In the towed buoy configuration, a hydrodynamic, torpedo shaped buoy houses a satellite/GPS unit and trails behind the whale. In the charm tag configuration, the tow tether is shortened such that the electronics package is integrated directly into the harness. Multiple redundant release systems (electronic timed release, galvanic timed release, and breakaway link) are incorporated in the harness to ensure that the harness releases from the whale allowing the whale to go gear-free should a problem arise.

Pole deployed peduncle tag for small whales
For small whales, two different prototype peduncle tags were developed: 1) a form-fitting, hydrodynamically fared, semi-rigid saddle pack tag that sits on the dorsal ridge of the peduncle just before the fluke insertion, and 2) a loose belt “charm” tag similar to the large whale system. The saddle pack tag is modeled after a typical equestrian saddle (Figure 2). Just as a rider's weight is distributed to either side of the horse's spine, the whale saddle incorporates a gullet space over the dorsal ridge and "bars" to distribute the weight and pressure of the saddle pack onto the sides of the peduncle rather than the dorsal ridge itself. The fore and aft portions of the gullet are also slightly rockered to give even more room for the body to flex without the dorsal ridge coming in contact with the saddle. To provide protection against chafe, the underside of the saddle and the girth are lined with ultra-soft, shear-resistant padding. A small lower saddle unit is also used to protect the ventral ridge of the peduncle. The loose belt configuration was developed as an alternative to the fitted saddle (Figure 3). In this case, the belt consists of a loose strap of webbing encased in a gel sleeve. A short tether connects the tag electronics to the harness. The small whale systems use a hand pole with a pneumatically powered armature for tag deployment. Once triggered, the armature’s sickle shaped arms close, latching a buckle around the caudal terminus of the whale. In the saddle configuration, the harness is cinched as the arms lift away to snugly secure the saddle to the dorsal ridge of the peduncle. For the loose belt, the clip is merely closed without cinching. An electronic timed release combined with a backup corrosive galvanic release form a redundant release system for reliably removing the harness and tag system at a pre-set time. A breakaway link will also be included to minimize entanglement risk and ensure that the belt releases from the whale should the harness become fouled on any gear or other debris in the water.

System designs will be done in-house at the University of Maine. B. Woodward will lead the project working with J. Winn to design, fabricate and test the two tagging systems. M. Moore from Woods Hole Oceanographic Institution will provide veterinary expertise, advising during the tag development process and evaluating potential impacts of the tag once in the field.

WORK COMPLETED

- Refined the large whale lasso and net gun deployment system based on the results of the 2010 field effort
    - Increased the capture area size of the lasso by 40%
    - Enhanced the capability (both power and capacity) of the retraction device
    - Refined the gun and gun mount to allow 360 degrees of rotation and a tilt function for improved aiming and ranging capability

    - Expanded the net gun deployment system capability to include both the charm tag and towed buoy tag configurations with the peduncle attachment

- Conducted field trials of net gun deployed peduncle tag on humpback whales in the Bay of Fundy in summer 2011

- Developed and tested prototype small whale saddle pack and loose belt peduncle tag configurations on captive animals with different morphologies and skin characteristics
    - Slow swimming, thicker skinned beluga whale at Mystic Aquarium
    - Faster swimming, thinner skinned false killer whale and bottlenose dolphin at Hawaii Institute of Marine Biology

RESULTS

Net gun deployed large whale peduncle tag
Based on the 2010 field effort, the majority of this year's development effort focused on enhancing the ability to loop the tail – primarily through improving the aerodynamics of the lasso flight, increasing the capture area size of the lasso and improving the aiming and ranging capabilities of the gun. The lasso size was increased by 40%, and the lasso bucket and gun mount frame were modified to allow 360 degrees of rotation of the gun plus a tilt function to allow for near versus far shots. On-the-water tests were very positive in terms of accurately ranging and lassoing a target on the local river.

The power and capacity of the retraction device was also enhanced. On-the-water tests showed a substantial reduction in retraction speed due to drag on the line as it is pulled through the water as opposed to on land. The retractor tube was modified to double the pulling capacity (now 45 ft of line) to accommodate the larger lasso size and increasing the power house of the system to nine 150lb extension springs compared to the two used in the original 2010 system. The net gun deployment system capability was also expanded to include both the charm tag and towed buoy tag configurations with the peduncle attachment (Figure 4).

The system was taken to the field in August 2011 to test it on humpback whales in the Bay of Fundy. It turns out that there was a marked scarcity of whales during the 19-day field effort. As such, only 5 lasso attempts were possible this year (compared with 7 last year and 18 made in 2009). However, the modifications made to the net gun deployment system appear to have addressed the aiming and ranging problems encountered in 2010. This year 4 out of 5 attempts looped the tail – a success rate of 80% - compared with 0 out of 7 attempts in 2010. The larger lasso size and gun mount modifications significantly improved the net gun's ability to reliably loop the tail.

There are still some issues to address. Out of the 4 shots, two had problems with the breakaway link in the harness breaking during the launch process and two had problems with the retractor (one tangle as the line pulled in (Figure 5), one misfire due to a mechanical misalignment of the release pin). These issues can be addressed with a few simple changes and further refinement of the retractor. Refinements for 2012 include increasing the reliability of the retraction system, streamlining the lasso to eliminate potential tangle points, refining the breakaway link to prevent breakage during launch, and adding check points and lock downs so system can be transported in an armed and ready-to-fire state to maximize tagging time.

As with any new tagging technique, it takes time and some trial-and-error to learn the intricacies of approach technique and whale behavior/response. The system is now at a point where the boat can be effectively positioned and the tail looped. Retraction testing is the next key item for successful tag deployment. Despite testing with a model tail, it is difficult to anticipate all scenarios which may arise in active tagging situations with animals in the wild. As such, additional sea trials are necessary to effectively analyze and refine the deployment system.

For the past several years, field work has been conducted in the Bay of Fundy due to the lengthy US permitting process. However, the success of the field efforts has been severely hampered by the sparseness of whales in the study area. In 2010 only 7 tagging attempts were made, and only 5 attempts were possible in 2011. The lack of animals made it difficult to effectively test the system. Options for alternative study area sites to increase the number of whales and hence the number of tagging opportunities – either on Stellwagen Banks in the US or adding right whales to the Canadian permit – will be explored for 2012.

Pole deployed small whale peduncle tag

The two versions of the small whale peduncle tag (the saddle pack tag and the loose belt charm tag) were tested on several species of captive whales to determine performance characteristics on both fast and slow swimming species with differing peduncle morphologies and skin characteristics. Testing was conducted at Mystic Aquarium on a 29 year old female beluga whale, and at the Hawaii Institute of Marine Biology on both an adult (> 30 years old) female false killer whale and a 26 year old female bottlenose dolphin. After an initial period of acclimation, the animals were asked to perform a number of behaviors under trainer control. The energetic effort associated with the behaviors was gradually increased to include recalls from A to B, speed swims, dorsal and ventral tail slap swimming, tail walks, and aerial jumps (Figure 6). Deployment times were also increased to include free swim time where the whale was no longer under trainer control. Whale behavior did not appear to be affected by the tag presence either during the training sessions or during the free swim periods. The whales did not attempt to rub the tag off, and trainers indicated that behaviors were consistent with “normal” swim patterns.

Different tag configurations (loose belt versus saddle pack) are better suited to a species depending on the whale’s typical swim behaviors (fast or slow) and their skin and peduncle morphology. The beluga peduncle morphology offers a wider and taller surface area with thicker and tougher skin. With their slower swim behaviors and softer, spongier tissue consistency, their morphology and behaviors allow them to accommodate either the more rigid saddle pack tag or the loose belt configurations.

The maximum continuous duration of a tag carry for the saddle pack tag for the beluga was 5 hours and 45 minutes. During the 4 training sessions of the day, the whale was asked to perform energetic swim behaviors. The whale then had a 1hr 45min free swim in the main pool with nearly continuous swimming activity. During the remaining free swim periods, the whale was gated in the holding pool due to gating constraints with the other whales at the exhibit. In the holding pool, the whale spent most of her time head bobbing or logging near the surface – typical behaviors for this whale. No chafe was noted on the dorsal or ventral ridges or on the leading edge of the fluke blade at the end of the tag deployment (Figure 7). The loose belt configuration was also tested. Tag deployment time was 1 hr 35min including 2 training sessions with high energy behaviors and one free swim of 1hr in the main pool. Again no chafe of the peduncle was visible.

Conversely, false killer whale skin tissues were found to scuff and mark very easily – even through free choice activities of rubbing against the rub rope in the pen. The quicker, more aggressive tail movements of the pseudorca coupled with their thinner skin and stiffer peduncle tissues tend to concentrate the forces of the snug belt at the peduncle/ fluke juncture leading to chafing issues. On the other hand, the beluga skin appeared to be much tougher and abrasion resistant. The softness and sponginess of the peduncle tissues themselves tended to act as an absorption mechanism for friction and shear for the beluga whereas the harder/firmer tissues of the pseudorca peduncle did not. For this reason, the loose belt presents a better option for the faster moving, thinner skinned species such as the false killer whale and bottlenose dolphin. Rather than concentrating the belt load at the peduncle/fluke juncture where the motion of the skin tissues is highest, the loose belt drapes back over the leading edge of the fluke away from the body juncture (Figure 8). The toughness of the leading edge fluke tissue appears to increase moving outward from the body juncture and in and of itself, is not flexing as the whale swims. This leads to less chafe from the belt even though it is loose and can move around. Only minimal light polishing of the pseudorca skin was observed after an hour of activity while wearing the loose belt. The loose belt was also deployed on a bottlenose dolphin for a period of 16 minutes with high activity and multiple aerial jumps. No marks were found on the peduncle or fluke tissues.

The loose belt configuration offers a number of advantages over the saddle pack tag. The loose belt lends itself to a potentially easier tag deployment particularly for the faster moving species which tend to bow ride. In these instances a pneumatic armature could be used on a hand pole to clip a loose belt about the peduncle of a bow riding animal. It is also orientation independent and there is no risk of it slipping off the peduncle ridge and starting to dig in. It allows water flow across the skin tissues to keep the skin cool, and it does not have the risk of pressure necrosis like a snug belt. On the other hand, a snug belt guarantees the antenna orientation for potential satellite tracking studies.

Overall, the testing of the peduncle belt at Mystic Aquarium and the Hawaii Institute of Marine Biology suggests that the peduncle belt works well in a captive setting for short durations of high activity on multiple species with extremely varying skin types. Both the fitted saddle pack and the loose belt options show great potential for a peduncle attachment on beluga whales whereas the loose belt option appears to be better for faster moving species. With further development, the peduncle belt offers good potential as medium-term non-invasive tag attachment mechanism. The next phase of testing would be to increase tag deployment times and swimming effort to more closely simulate deployment on a wild animal, yet still maintain the ability to closely monitor the skin tissues of the peduncle and flukes. Based on the preliminary results from the bottlenose dolphin testing in Hawaii, it appears that Tursiops may be a good representative for high speed swimmers with thin skins. Longer duration tests may be possible on animals housed in lagoons/coves with large swim areas and/or animals trained for open ocean tests. Options for more extended test scenarios will be explored.

IMPACT/APPLICATIONS

It is anticipated that the peduncle belt will provide a versatile tag attachment platform that is applicable to many medium to long-term cetacean tagging studies for both large and small whale species. The system is designed to be easily adjustable to accommodate a wide variety of species (beaked whales to baleen whales), tag electronics packages (satellite/GPS location tags to multi-sensor data loggers with acoustic recording capabilities), and tag deployment lengths (weeks to months to years) to meet the desired experimental design. From long term migration pattern studies to controlled exposure

behavioral response studies, the peduncle belt shows great potential as an alternative noninvasive, recoverable tag attachment platform.

RELATED PROJECTS

There are no related projects.

Figure 1. Large whale tag deployment system. Net gun deploys a 10x15ft lasso as the whale flukes out on a terminal dive. Once the loop closes, a 10ft padded harness encircles the peduncle and acts as an attachment point for an electronic tag package.

Figure 2. Small whale saddle pack tag on a beluga whale. A) Dorsal saddle houses a time/depth recorder and VHF beacon. B) Semi-rigid saddles protect the dorsal and ventral ridges of the peduncle while the silipos gel sleeve works to minimize potential chafe of the girth on the leading edge of the fluke.

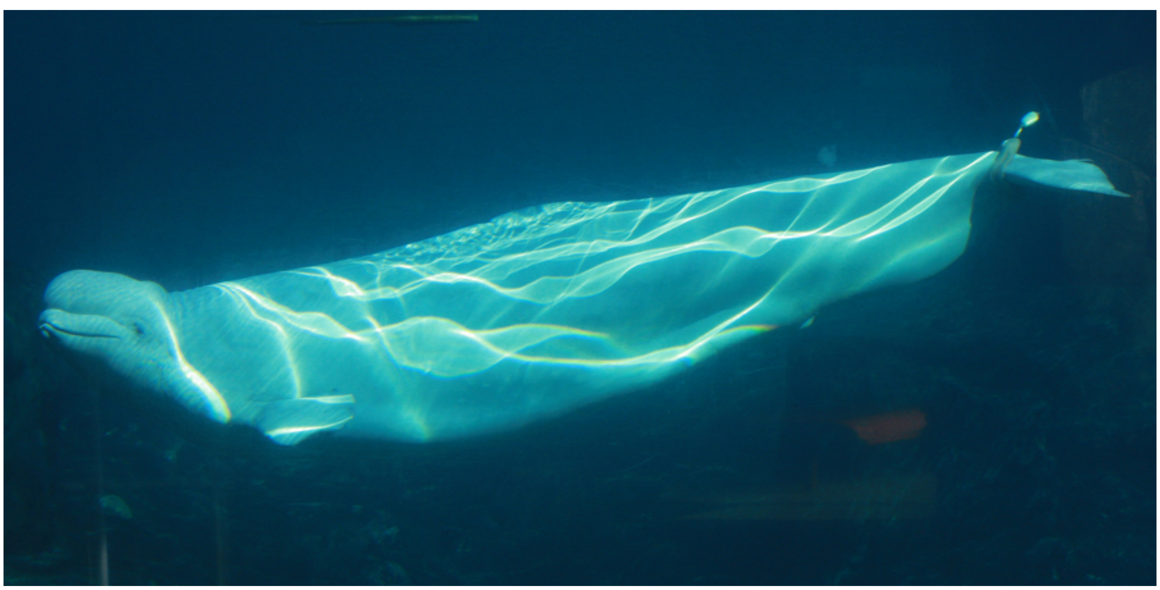

Figure 3. Loose belt tag configuration with tethered electronics package. The tethered tag has sufficient flotation to keep it off the whale's flukes as it swam.

Figure 4. Comparison of deployment system for: A) towed buoy configuration and B) charm tag configuration. For the towed buoy, both the tow tether and retractor line feed out during the deployment process. When the line comes taunt, the buoy launches from the side tube. For the charm configuration, the tag and VHF beacon are suspended by hooks in the lasso line. As the retractor pulls in, the hooks release and the lasso cinches closed. In both cases, the retractor pulls the loop closed, engaging the breakaway link on the harness and releasing the lasso line and associated weights from the whale. This "breakaway roping" allows the whale to swim free with only the padded harness encircling the peduncle.

Figure 5. Tangle at the eye of the lasso. Line completely encircled the peduncle, but tangled at the eye during the retraction process.

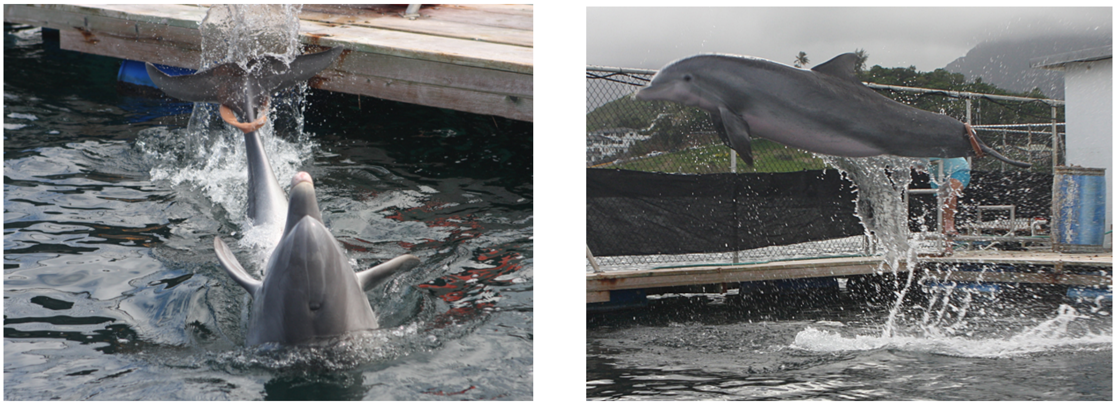

Figure 6. Bottlenose dolphin with loose peduncle belt performing energetic activities: ventral tail slap swim (left) and aerial jump (right).

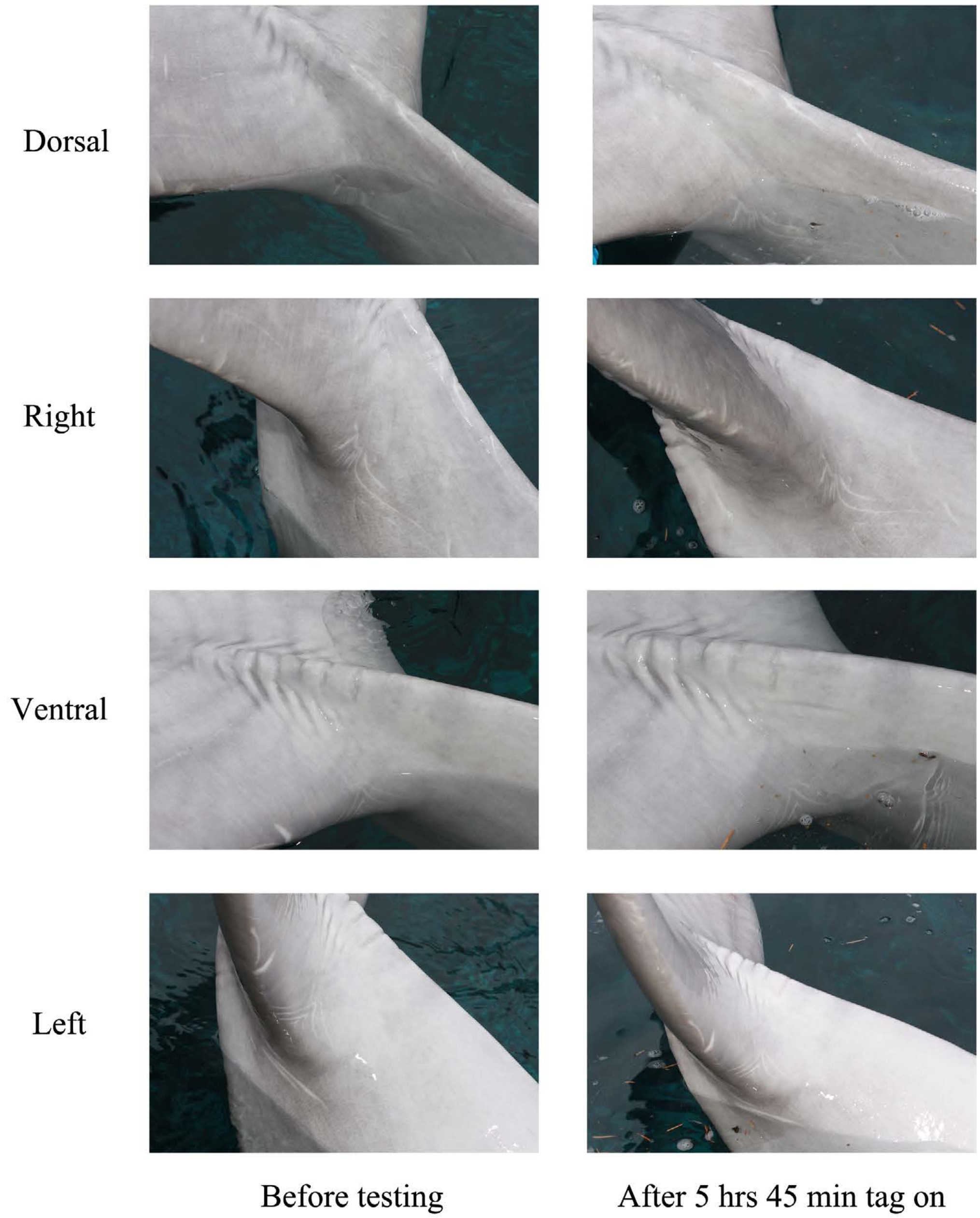

Figure 7. Comparison of the dorsal and ventral ridges as well as the peduncle fluke junction both before and after a 5 hr and 45 min saddle pack tag deployment. No new scuffing or chaffing is evident.

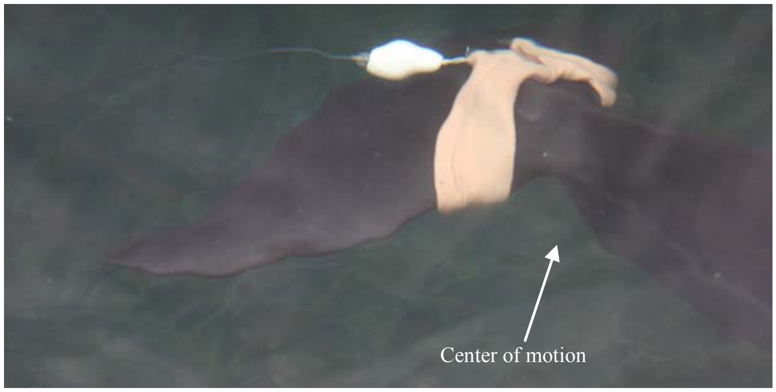

Figure 8. Loose belt on pseudorca. Loose belt drapes over the leading edge of the fluke, distributing the load from the tag away from peduncle/fluke junction where the motion of the fluke blade originates.